PAGE
0035738

Rockwell Hanford Operations

SUPPORTING DOCUMENT

Number	Rev. No.	Page A of 1333 Total Pages
SD-HS-SAR-001	Rev 5	

PROGRAM: Health, Safety and Environment

Baseline Document ☐ Yes ☒ No

Document Title: PUREX Plant Final Safety Analysis Report

WBS No. or Work Package No.: KP29N

Key Words: PUREX, Final Safety Analysis Report

Prepared by (Name, Dept. No. and Signature)

J. J. Roemer
J. J. Roemer 12723

See reverse side for additional approvals

Abstract

This Final Safety Analysis Report (FSAR) addresses health, safety, and environment protection matters pertaining to the operation of the PUREX Plant located in the U.S. Department of Energy Hanford Site.

This document fulfills the requirements of DOE Order 5480.1A, Chapter V.

A Preliminary Hazards Analysis is presented. These hazards were reviewed by personnel experienced in the operations of the PUREX Plant. Comparison of the predicted accident consequences with established criteria result in the judgment that PUREX Plant operations may be conducted with an acceptable level of risk.

NOT FOR PUBLIC DISSEMINATION

MAY CONTAIN UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION SUBJECT TO SECTION 148 OF THE ATOMIC ENERGY ACT OF 1954, AS AMENDED (42 USC 2168). APPROVAL BY THE DEPARTMENT OF ENERGY PRIOR TO RELEASE IS REQUIRED.

THIS IS A PAGE CHANGE DOCUMENT AND SHALL BE INCORPORATED/ATTACHED TO THE FRONT OF THE LATEST COMPLETE RELEASED DOCUMENT.

*	Distribution Name	Mail Address
	DOE-RL	
*	R. E. Gerton	Fed/700
*	D. P. Simonson	Fed/700
*	D. M. Smith	Fed/700
	PNL	
*	S. M. Gilchrist	RTL/300
	Rockwell	
	J. F. Albaugh	2750E/200E
*	D. K. Bailey	MO-405/200E
	D. C. Bartholomew	2750E/200E
*	R. C. Beagley	2753E/200E
	G. F. Boothe	2751E/200E
*	H. N. Bowers	2753E/200E
*	C. L. Brown	2751E/200E
*	R. C. Brown	622G/600
	F. T. Calapristi Sr.	2704S/200W
*	G. M. Christensen	2750E/200E
*	A. C. Crawford	2750E/200E
	P. Dessaules	234-5/200W
*	C. V. DiPol	2750E/200E
*	G. T. Dukelow	202A/200E
*	J. F. Durnil	234-5/200W
*	J. H. Ellis	202A/200E
*	D. G. Harlow	2750E/200E
*	D. C. Hedengren	MO-405/200E
*	M. E. Hevland	2751E/200E
*	E. J. Kosiancic	2750E/200E
*	R. A. Kulick	MO-405/200E
	P. G. Lorenzini	2750E/200E
	R. Y. Lyon	2751E/200E
	C. W. Manry	2753E/200E
*	W. E. Matheison	2751E/200E
*	J. D. McIntosh	202A/200E
*	J. K. McClusky	MO-047/200E
*	F. D. Nankani	HAPO/1100
	S. M. Nielson	2751E/200E
*	D. K. Oestreich	2751E/200E
*	G. C. Owens	2751E/200E

(Continued on reverse side)

*COMPLETE DOCUMENT
(No asterisk, title page/summary of revision page only)

Rockwell Hanford Operations

Page	Number	
B	SD– HS-SAR-001	**SUPPORTING DOCUMENT**

Approvals

- [x] Program Office
- [x] Research and Engineering
- [x] Plant Operations — 1-15-87
- [x] Safety (of Safety and Quality Assurance) — 1/15/89
- [x] Quality Assurance (of Safety and Quality Assurance) — 1-15-87
- [x] Nuclear Criticality Safety Committee Approval Authority — 1/15/87
- [ ]
- [ ]
- [ ]
- [x] Safety and Quality Assurance, Director — 1/15/87
- [x] Chemical Processing, Director
- [ ] Chemical Processing Safety Committee Approval Authority
- [x] Approval Authority

* Distribution	Name	Mail Address
*	K. E. Plummer	MO-405/200E
*	P. D. Rittman	2751E/200E
*	E. D. Robbins	MO-407/200E
*	J. H. Roecker	2750E/200E
*	J. S. Sprouse	2750E/200E
*	G. C. Strickland	MO-405/200E
*	R. W. Szempruch	MO-405/200E
*	D. L. Uebelacker	MO-409/200E
*	R. E. Van der Cook	MO-405/200E
	E. C. Vogt	2751E/200E
*	S. A. Wiegman	2751E/200E
*	R. L. Walser	MO-023/200E
*	Safety Analysis Files (2)	2751E/200E
*	Technical Publications (2)	
	J. E. Brown	2751E/200E
*	G. L. Jones	2751E/200E

Summary of Revision

Complete Revision ______ Page Change X

DESCRIPTION OF CHANGE

Section 11.1.4.1 is revised to reflect the initial actions and recovery for criticality violations as stipulated in RHO-MA-136.

Section 11.3.1.3 is revised to make the double contingency principle of criticality control a safety condition.

Section 11.3.1.5 is revised by the addition of paragraph J regarding criticality prevention specifications.

Section 11.3.5.5 is revised by the addition of paragraph P which requires up-to-date, legible, red-line drawings.

11.0 OPERATIONAL SAFETY REQUIREMENTS

11.1 INTRODUCTION

11.1.1 Applicability and Objectives

The Operational Safety Requirements (OSR) herein, in accordance with U.S. Department of Energy (DOE) Order 5480.1A, Chapter V, define acceptable conditions, safe boundaries and bases, and management controls required to ensure safe operation of the Plutonium-Uranium Reduction Extraction (PUREX) Plant during the processing of irradiated fuels.[1] Operations outside of the specified boundaries and conditions could result in an unacceptable level of risk to the public, site workers, or environs or a compromise of facility integrity.

11.1.2 Definitions

The OSR are divided into the three following categories.

- Safety Boundaries

  Safety Boundaries refer to the values of safety-related process variables which are observable and controllable. Operation outside of a safety boundary may result in serious consequences.

- Safety Conditions

  Safety Conditions refer to those technical conditions or restrictions essential for safe operation.

- Control Features

  Control Features supporting each safety boundary and safety condition are delineated in this document. Specific Limiting Control Settings (LCS) and Limiting Conditions for Operation (LCO) to implement each of these control features are defined in internal Rockwell Hanford Operations (Rockwell) documentation.[2] The LCS and LCO define the minimum equipment operability requirements, repair schedules, operability testing or calibration schedules, and more conservative operating limits.

11.1.3 Operational Safety Requirements Violations

The following items are OSR violations:

- Operating outside of a safety boundary
- Failing to meet the requirements of a safety condition
- Failing to have a specific control feature in place
- Failing to implement a recovery statement for exceeding a control feature requirement.

11.1.4 Corrective or Responsive Action

A violation of a safety boundary or safety condition would normally be detected at the time of occurrence since the specific control features provide early warning. Violation of a safety boundary or safety condition could also be detected after the fact during routine process control review or periodic audit. Failure to have a specific control feature in place should be detected and corrected during the prestartup review or would be detected after the fact. Actions to be taken in response to OSR violations detected at the time of occurrence are delineated in Section 11.1.4.1. Response to violations detected after the fact is defined in Section 11.1.4.2.

11.1.4.1 Violation Detected at Time of Occurrence. When an OSR violation is detected at the time of occurrence, the following action shall be taken.

- The affected process shall be brought to an orderly shutdown; this may require shutdown of the entire facility. Recovery from a criticality prevention specification violation shall be in accordance with an approved written plan per RHO-MA-136 (Ref. 20).
- The following people (by position) shall be promptly notified: Manager, PUREX Process Operations; Manager, PUREX Operations; Manager, PUREX Process Control; appropriate Department Manager, Safety and Quality Assurance (S&QA) Chief, Nuclear Processing Branch, DOE-RL.
- Rockwell shall investigate the violation, recommend corrective actions to prevent further violations, and prepare an unusual occurrence report. This report shall be reviewed by the appropriate Rockwell safety committee and the DOE-Richland Operations Office (RL).

11.2.9.5 <u>Control Features</u>. Plutonium dioxide powder is hygroscopic and readily adsorbs sufficient moisture from the air to cause container pressurization. The dry product powder is exposed to the glovebox atmosphere in the powder handling and the loadout gloveboxes. To ensure that the air in those gloveboxes is sufficiently dry to prevent the adsorption of moisture by the product, the atmospheric moisture is limited.

The rate of the prereduction reaction and therefore the rate of gas generation can be controlled by placing restrictions on nitric acid and hydrogen peroxide concentrations and reaction temperature. This will limit pressurization of the prereduction tank.

Tests such as "loss on ignition" readily detect the presence of unstable compounds which could result in container pressurization.

The operability/calibration program assures that the mitigation conditions assumed are functioning. Specific control features follow.

A. Prior to further processing in the plutonium oxide production facility, a sample of each plutonium nitrate feed solution batch shall be visually inspected to verify there is no separate organic phase.

B. The maximum allowable moisture content shall be defined for the powder handling and loadout glovebox atmospheres.

C. Operational controls shall be defined to limit pressurization of the prereduction tank, calciners, and other process vessels.

D. Operational controls shall be established to avoid storage of unstable plutonium compounds in sealed containers.

E. Minimum equipment operability requirements and repair schedules shall be established to support these control features.

F. Operability testing/calibration schedules for equipment and instruments required to support these specific control features shall be established and executed.

11.3 SAFETY CONDITIONS

The safety conditions apply to those technical conditions or restrictions which are essential for safe operation. The safety conditions pertain to those process or operating conditions necessary to preclude the occurrence of a serious incident or to ensure that normal operations can be maintained within the confines of release guides. Operation of the plant or process under conditions outside the scope of the safety conditions could result in hazard to the public, environment, or operating personnel. An infraction of a safety condition, therefore, requires the immediate notification of DOE-RL and the prompt, orderly shutdown of the affected portion of the processing operation. Depending upon the affected operation, it may be necessary to shut down all production processing activities.

11.3.1 Nuclear Criticality Prevention

11.3.1.1 Applicability. This safety condition applies to all processing and handling of fissile material in the PUREX Plant.

11.3.1.2 Objective. The objective is to prevent the occurrence of a nuclear criticality accident.

11.3.1.3 Safety Condition. Fissile material shall be controlled so that at least two unlikely, independent, and concurrent changes in conditions must occur before an accidental nuclear criticality is possible.

11.3.1.4 Bases. Department of Energy Order 5480.5[1] requires that fissile material be processed, stored, transferred and handled in a manner that minimizes the possibility of a nuclear criticality accident. Within Rockwell, the criticality safety program is defined in the Nuclear Criticality Safety Standards manual.[20] Each fissile material operation is considered in detail. Credible contingencies that could potentially lead to a criticality accident are identified, evaluated, and documented. Criticality prevention limits are then established and implemented.[21]

- In shielded facilities, criticality prevention is based on the double contingency principle which holds that at least two unlikely, independent, and concurrent changes (contingencies) must occur before criticality is possible.
- In unshielded facilities, criticality prevention is based on the triple contingency principle which holds that at least three unlikely, independent, and concurrent changes (contingencies) must occur before criticality is possible.
- In establishing controls to assure compliance with the contingency criteria, the margin of subcriticality meets one of the following:
  - The k_{eff}* is less than 0.95, including allowances for biases in the calculations (if the method of calculation can be shown to be accurate by comparison to experimental data for a similar system, a higher value may be justified and approved; under no circumstances shall a k_{eff} of 0.98 be exceeded)

*If a Monte Carlo method is used to calculate K_{eff}, the reported value will be the calculated $K_{eff} + 2\sigma$, where σ is the standard deviation.

- The fraction of critical dimension, volume, mass, etc., including an allowance for accuracy, is equal to or less than 0.90

- The evaluated parameter is equal to or less than a corresponding subcritical limit given in American Nuclear Society standards or guides.[20]

- Criticality prevention may be achieved by limiting one or more of the following items:

  - Equipment geometry--shape and dimensional limitations--including allowances for corrosion, tolerances, etc.

  - Fissile material mass, including allowances for measurement accuracy (particularly using NDA methods)

  - Fissile material volume

  - Fissile material form

  - Fissile material concentration or density

  - Fissile material moderation

  - Presence of fixed or soluble neutron absorbers (poisons)

  - Arrangement and spacing of equipment

  - Reflection.

  Where practical, reliance is placed on equipment design in which dimensions are limited, rather than on administrative control. Full advantage may be taken of any nuclear characteristics of the process materials.

- Criticality limits take into account neutron interaction between systems or individual units (e.g., individual fissile material batches, containers, or vessels), unless the systems are isolated.

11.3.1.5 Control Features. The control features assure that all fuel types proposed for processing in the PUREX Plant are analyzed for criticality implications and specifications are established before approval to proceed is given. Controls on the dissolver operation are established to prevent excessive plutonium concentrations, plutonium precipitation, and plutonium polymer formation. Limits on plutonium rework added to TK-E6 maintain the plutonium concentration in the solvent extraction feed within an acceptable range. The sample schedule and instruments are used to monitor process performance and prevent plutonium reflux or undesired accumulation in solvent extraction equipment. The equipment operability requirements and the operability testing/calibration program assure that the mitigating conditions assumed in the analysis of postulated criticality accidents are functioning. Specific control features follow.

A. Analyses shall be performed for materials with specific ^{235}U enrichments and minimum ^{240}Pu isotopic contents prior to processing.

B. The procedures shall require dissolvers to be inspected following dissolution to prevent overcharging.

C. The dissolver sequence selector switch and specific gravity interlocks shall be used to control allowable additions to and transfers from the dissolvers per flowsheet sequence.

D. The nitric acid concentration and plutonium content of the metal solution at the end of the dissolution step shall be controlled based on dissolver specific gravity readings.

E. The amounts, concentrations, and conditions for rework of plutonium via feed makeup tank TK-E6 shall be specified.

F. An approved sample schedule shall be issued which identifies samples required to support the criticality prevention program.

G. Nitric acid monitors, flow monitors, plutonium concentration monitors, and interlocks shall be identified to supplement the sample schedule and provide an additional safety margin.

H. Minimum equipment operability requirements and repair schedules shall be defined to support the criticality prevention program.

I. Operability testing/calibration schedules for equipment and instruments required to support these specific control features shall be established and executed.

J. Criticality prevention specifications shall be in place for PUREX operations.

D. Limits shall be established for the chemical composition of the process condensate (pH) and chemical sewer (pH and cadmium) streams.

E. Controls to prevent the presence of a separate organic phase in any radioactive liquid effluent stream shall be established.

F. Minimum equipment operability requirements and repair schedules shall be defined to support the liquid effluent disposal program.

G. Operability testing/calibration schedules for equipment and instruments required to support these specific control features shall be established and executed.

9412319.499

11.3.5 Administrative Control System

11.3.5.1 Applicability. This safety condition applies to the administrative control system required for operation of the PUREX Plant.

11.3.5.2 Objective. The objective is to assure safe operation of the PUREX Plant during both normal operations and under accident conditions.

11.3.5.3 Safety Condition. An administrative control system shall be defined for the PUREX Plant which assures safe operation under both normal and accident conditions.

11.3.5.4 Bases. The safe operation of a processing facility depends upon personnel of various talents, each performing the assigned task in accordance with established procedures, rules, and controls. For the staff to operate the facility successfully, there must be an assignment of responsibility and delegation of authority. To ensure a safety consciousness throughout the organization, safety standards and objectives plus a procedural system for implementation and an education and training program covering the content and application thereof must be provided.

11.3.5.5 Control Features. The specific control features are listed below. The criticality prevention, gaseous effluents, and liquid effluents controls discussed in Sections 11.3.1, 11.3.3, and 11.3.4; and the Accident Prevention Standards Manual[27] are required to assure safe operation of the PUREX Plant. These controls assure that a qualified and trained staff is available at all times and is capable of safely shutting down the plant if necessary to remain within limits evaluated in the EIS and FSAR. Procedures are provided for both normal and emergency shutdown conditions. The mitigating conditions assumed in the accident analyses are assured by the design control and operability testing/calibration requirements. Adequate records and audits are available as proof of safe operation and compliance with this OSR. Specific control features follow.

A. An organization plan shall be established which provides an effective management system for the PUREX Plant and supporting organizations.

B. Minimum qualifications shall be established for operating and support personnel.

C. A minimum shift staffing plan shall be established which assures that the plant can be shut down safely under accident conditions.

D. A documented training program shall be established.

E. Plant operating procedures shall be prepared to ensure operation within the scope of the OSR specified herein.

F. A surveillance, operability testing/calibration program for all equipment and instruments required to support specific control features shall be established and executed.

G. An emergency plan and emergency shutdown procedures shall be established and maintained in appropriate locations.

H. An ALARA program plan shall be established.

I. Records shall be maintained by PUREX Operations Department to provide auditable proof that operations are conducted within the safety boundaries and safety conditions.

J. An internal Rockwell document containing LCS and LCO shall be prepared to implement the control features contained in this OSR.

K. Audits of the conduct of the operations and support activities shall be made.

L. The design or design modifications of any equipment item or system related to environmental, personnel, or process safety shall receive prior engineering and safety review and approval.

M. The requirements for storing and handling chemicals shall be defined.

N. The requirements for disposal of solid waste materials with the potential for containing radionuclides shall be defined.

O. Minimum operability requirements and repair schedules for pressurized air supply systems and essential services (electricity, steam, water) equipment shall be defined.

P. A program for maintaining up-to-date controlled master drawings, by red-line change, for all instrument engineering flow diagrams (IEFD) and cell arrangement drawings (CAD) needed to support specific control features and/or routine plant operation shall be established and executed.

11.4 REFERENCES

1. DOE, "Safety of Nuclear Facilities," DOE Order 5480.5, Department of Energy, Washington, D.C. (September 23, 1986).

2. Rockwell, PUREX Process Control Manual, RHO-RE-MA-5, Rockwell Hanford Operations, Richland, Washington (1983).

3. Threshold Limit Valve (TLV) for Chemical Substances-and Physical Agents in the Work Environment with Intended Changes for 1982, American Conference of Governmental and Industrial Hygienists, (Current Version).

4. Limits of Flamability of Gases and Vapors, U.S. Bureau of Mines Bulletin 503, U.S. Government Printing Office, Washington D.C. (1952).

5. L.V. Carlson, R. M. Knight, J. O. Henrie, Flame and Detonation Initiation and Propagation in Various Hydrogen-Air Mixtures, with and without Water Spray, AI-73-29, Rockwell International Atomics International Division, Canoga Park, California (May 12, 1973).

6. F. R. Belles, Detonability and Chemical Kinetics: Prediction of Limits of Detonability of Hydrogen, 7th Symposium on Combustion at London and Oxford, the Combustion Institute, Butterworth Scientific Publications (August 28 to September 3, 1958).

7. J. S. Yeaw and L. Schnidman, The Extinction of Gas Flames by Steam, American Gas Association Twentieth Annual Convention, Atlantic City, N. J. Proceedings, American Gas Association, Inc., 420 Lexington Avenue, New York, N. Y. (October 10 to 13, 1938).

8. Rockwell, Heat Transfer Analysis - Fuel Canisters Stored in PUREX Canyon, SD-RE-TI-034, Rockwell Hanford Operations, Richland, Washington (July 23, 1982).

9. Flammability Characteristics of Combustible Gases and Vapors, Bureau of Mines Bulletin 627, U.S. Department of the Interior, Bureau of Mines, Washington, D.C. (1965).

10. Rockwell, Bases for PUREX Solvent Tank Temperature Limits, SD-RE-TI-103, Rockwell Hanford Operations, Richland, Washington (July 1983).

11. Rockwell, Essential Material Specification EMS-G-00669, Normal Paraffin Hydrocarbon (NPH), Rockwell Hanford Operations, Richland, Washington (May 1983).

12. Richard Dennis, Handbook of Aerosols (1976).

13. Rockwell, Liquid Mixing and Processing in Stirred Tanks, Rockwell Hanford Operations, Richland, Washington (March 1978).

14. TNX-Evaporator Incident, DP-25, E. I. DuPont Co., Savannah River Laboratory (May 1953).

15. GE, Overconcentration in Initial Operation of Uranium Evaporator - 321 Building, HW-28690, General Electric Company, Richland, Washington (July 1953).

16. GE, Investigation of Explosive Characteristics of PUREX Solvent Decomposition (Red Oil), HW-27492, General Electric Company, Richland, Washington (March 1953).

17. Safety Aspects of Solvent Nitration in HTGR Fuel Reprocessing, GA-A14372, UC-77, General Atomic Company (June 1977).

18. GE, Denitration of PUREX Wastes with Sugar, HW-76973, General Electric Company, Richland, Washington (April 1963).

19. Rockwell, Evaluation of Food Pack Cans as Plutonium Storage Containers, ARH-CD-635, Atlantic Richfield Hanford Operations, Richland, Washington (March 1976).

20. Rockwell, Nuclear Criticality Safety Standards, RHO-MA-136, Rockwell Hanford Operations, Richland, Washington (July 1978).

21. Rockwell, Criticality Prevention Specifications--Uranium Plutonium Separations at the PUREX Plant, CPS-P-465-40000, Rockwell Hanford Operations, Richland, Washington (April 1983).

22. UNC, Isotopic Composition of Irradiated Mark IV and Mark 1A Fuel, UNI-436, UNC Nuclear Industries, Richland, Washington (September 29, 1975).

23. DOE, Operation of PUREX and Uranium Oxide Plant Facility, DOE/EIS-00890, Draft Environmental Impact Statement, U.S. Department of Energy, Washington, D.C. (May 1982).

24. DOE, "Requirements for Radiation Protection" DOE Order 5480.1A, Chapter XI, U.S. Department of Energy, Washington, D.C. (August 1981).

25. DOE-RL, Radioactive Waste Management, DOE-RL Order 5820.2, U.S. Department of Energy - Richland Operations Office, Richland, Washington (July 1979).

26. Code of Federal Regulations, 40-CFR-61.224, U.S. Government Printing Office, Washington, D.C.

27. Rockwell, Accident Prevention Standards Manuals, RHO-MA-221, Rockwell Hanford Operations, Richland, Washington (March 1979).